Condor

OPERATING MANUAL

MODEL 4501 / 4602

GROUP DELAY ANALYZER
DUAL TRACE DIGITAL DISPLAY

WAVETEK

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GROUP DELAY ANALYZER
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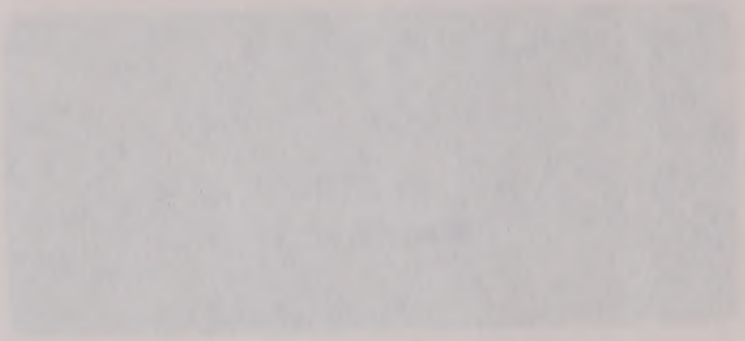

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1.1 INTRODUCTION

The Model 4501 Group Delay Analyzer, the Model 4602 Dual Trace Digital Display, and Model 2002B Sweep Generator constitute a group delay measurement system. This system makes use of less complicated AM measurement techniques and reduces some of the errors in previous systems of this type.

A unique feature of the system is that the group delay and insertion loss characteristics are displayed simultaneously on a dual-trace digital display. This feature permits real-time adjustment by an operator of components such as filters.

DIRECT READOUT OF GROUP DELAY

Model 4501 Group Delay Analyzer, which utilizes swept frequency techniques, reads group delay by measuring the phase shift of the modulating envelope of an amplitude modulated RF carrier as it passes through the device under test. This phase shift is converted to a voltage directly proportional to time delay, suitable for display on a long-persistence Model 4602 Display Oscilloscope. The signal may also be digitized and stored in memory when used in an automatic test system.

BROADBAND COVERAGE

Model 4501, when used with a Wavetek Sweep Generator and the Model 4602 Display Oscilloscope, indicates variations in group delay over the desired operating frequency of the device under test. This eliminates the time-consuming point-by-point measurements and elaborate computations. Model 4501 is a real time instrument where the effects of changes in group delay and passband insertion loss of the DUT may be observed as they occur. This is especially useful during manufacturing or when optimizing a device design.

11,000 NANOSECOND OFFSET

Small variations of less than 1 nanosecond may be observed in the presence of large group delays by offsetting as much as ±11,000 nanoseconds fixed group delay with front-panel controls. Wavetek Model 2002B Sweep Generator and the Model 4602 Display Oscilloscope are recommended for use with the Model 4501; although it may also be used with the Model 1080 Sweeper and any suitable X-Y Display Oscilloscope.

1.2 SPECIFICATIONS

MODEL 4501 GROUP DELAY ANALYZER

Frequency Range	5 to 1500 MHz
RF Input Level	3 dBm ±3 dB
Modulator Output Level (With +3 dBm input)	5 to 100 MHz: -20 dBm ±3 dB 100 to 1500 MHz: -17 dBm ±3 dB
Demodulator Input Level (30 dB dynamic range)	-42 dBm to -7 dBm
Insertion Loss	
Range	20 dB
Flatness (measured at maximum positive input slope)	5 to 1500 MHz: ±3 dB
Group Delay Range	30 dB (20 dB attenuation, 10 dB gain)
Frequency Response	5 to 20 MHz: ±20 ns 20 to 100 MHz: ±3 ns 100 to 1000 MHz: ±3 ns 1000 to 1500 MHz: ±3 ns
Accuracy	5 to 100 MHz: ±4.5% ±5 ns 100 to 1500 MHz: ±2% ±5 ns
Displayed Noise	Unfiltered: 2 ns rms Video Filtered: 1 ns rms
Connectors	Type "N" standard; other types optional
RF Terminal Impedance	50 or 75Ω (specify when ordering)
Output Dynamic Range	±2.5 V
Maximum Sweep Rate	10 Hz
Maximum Delay Offset	±11,000 ns
Calibrator Range	10, 100, 100 ns (No calibration routine if calibrated display is used.)
Output Drift	20 ns/hr after 1/2 hr warmup. (This will not affect a relative tg measurement.)
Automatic Offset and Drift Cancellation	Samples trace at center of sweep, compares to reference, and gates offset control to keep trace on screen.
Output Impedance	1000Ω DC coupled
Horizontal Input	0 to 10 V

GENERAL

Temperature Operating Range	25° ±5° C.
Dimensions	13.4 cm (5-1/4 in) high; 20.9 cm (8-1/4 in) wide; 48.3 cm (19 in) deep
Weight	7.2 kg (16 lb)
Power	115 or 230 V ±10%; 50 to 400 Hz; approximately 50 watts

MODEL 4602 DIGITAL DISPLAY

Display	CRT: 17.7 cm (7 in) diagonal display Pixels: 480 vertical by 512 horizontal (each channel) Phosphor: P39 Graticule: Electronically generated in a fixed graticule mode of 15 vertical lines by 12 horizontal lines

Vertical Channel (Channel A and Channel B)

Input Voltage Range:	(Four position selectable) 1.0 V/Div; 0.1 V/Div; 0.01 V/Div; 0.001 V/Div. Vernier control will have at least a 10:1 attenuation. Full clockwise (CAL position) will produce minimum attenuation.
Frequency Response	Analog: DC to 10 kHz Digital: Depends on max sweep rate of sweep generator used. At a sweep rate of 10 Hz, max input frequency should be limited to < 2.5 kHz. Slew Rate: 10 V/ms min.
Input Impedance	1 MΩ nominal shunted by 30 pF max
Vertical Position	Adjustable by a rear-panel control

Horizontal Channel	Sweep source is external to display coming from sweep generator being used.
Voltage Range	0 to 10 V
Sweep Rate	10 Hz max
Marker Channel	This channel is compatible with marker signals from Model 2002B or Model 2005 sweepers.
Detection Process	Envelope detection of marker. Minimum level: 1.2 Vpp

Display Mode	Marker display is implemented using pin-ball markers representing position of marker within sweep.
Dimensions	18.4 cm (7-1/4 in) high 20.9 cm (8-1/4 in) wide; 48.3 cm (19 in) deep
Weight	9.5 kg (21 lb)
Power	115 or 230 VAC ±10%; 50 to 400 Hz; approximately 85 watts

2.1 INTRODUCTION

This section provides necessary installation and operating instructions for the Model 4501 and Model 4602. The instructions include information on mechanical installation, electrical installation, front and rear panel features, operating procedures and a typical test setup.

2.2 MECHANICAL INSTALLATION

2.2.1 INITIAL INSPECTION

After unpacking each instrument, visually inspect external parts for damage to knobs, connectors, surface areas, etc. The shipping container and packing material should be saved in case it is necessary to reship the unit.

2.2.2 DAMAGE CLAIMS

If the instruments received have been damaged in transit, notify the carrier and either the nearest Wavetek area representative or the factory in Indiana. Retain the shipping cartons and packing materials for the carrier's inspection.

The local representative or the factory will immediately arrange for either replacement or repair of your instruments without waiting for damage claim settlements.

2.3 ELECTRICAL INSTALLATION

2.3.1 POWER REQUIREMENTS

The Model 4501, and Model 4602 can operate from 115 or 230 V ±10%, 50 to 400 Hz power mains. Before operating the instruments, make sure the proper fuse is installed and the correct line voltage is selected. See Figure 2-1.

Instruments shipped from the factory are set to operate at 120 VAC, 60 Hz unless specified otherwise.

2.3.2 PERFORMANCE CHECKS

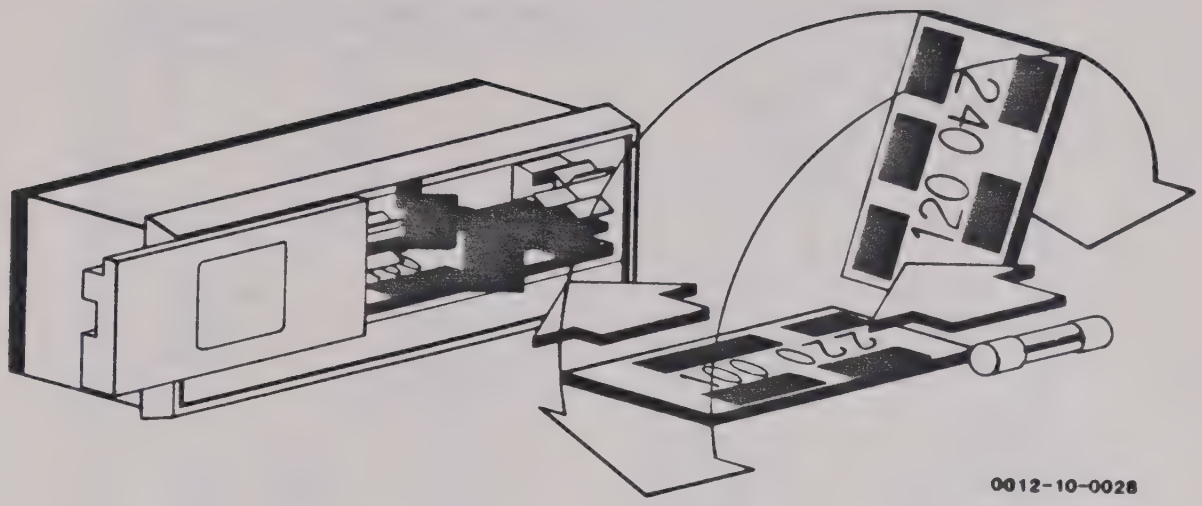
The electrical performance of this instrument should be verified prior to actual use. Performance checks for incoming inspection are given in Section 4 of this manual.

2.4 MODEL 4501 FRONT PANEL DESCRIPTION

See Figure 2-2.

1) AUTO OFFSET - This switch is turned on to assure an on-screen group delay trace when making relative group delay measurements. It is turned off when absolute group delay measurements are made. Its purpose is to automatically center the group delay signal around 0 volts.

2) COARSE CONTROL - This control is a 10-turn pot with 1 turn ≃ 2500 mV ≃ 2500 nanoseconds (ns) of vertical



Remove the line cord and slide the window all the way to the left. Remove the voltage-selector card. Orient the voltage-selector card so that the desired voltage is in the upper left and push the card firmly into the slot. Swing the lever to the right and check that the selected voltage is visible. Replace the fuse, slide the window to the right, and replace the line cord.

NOTE

Check that the fuse is the proper value for the selected voltage (see Section 2.5 and 2.7).

For 115V ±10% operation 120 should be displayed on the voltage selector card.

For 230V ±10% operation 240 should be displayed on the voltage selector card.

Figure 2-1. Line Voltage Selection

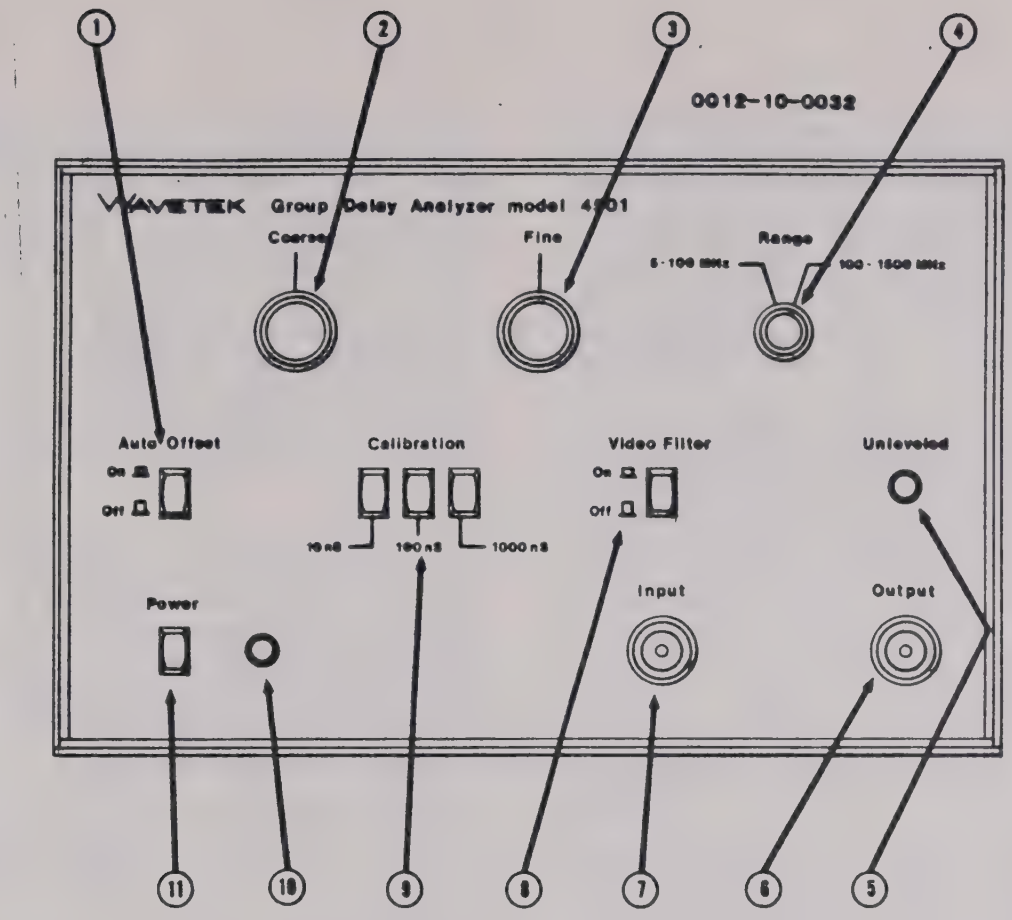


Figure 2-2. Model 4501 Front Panel

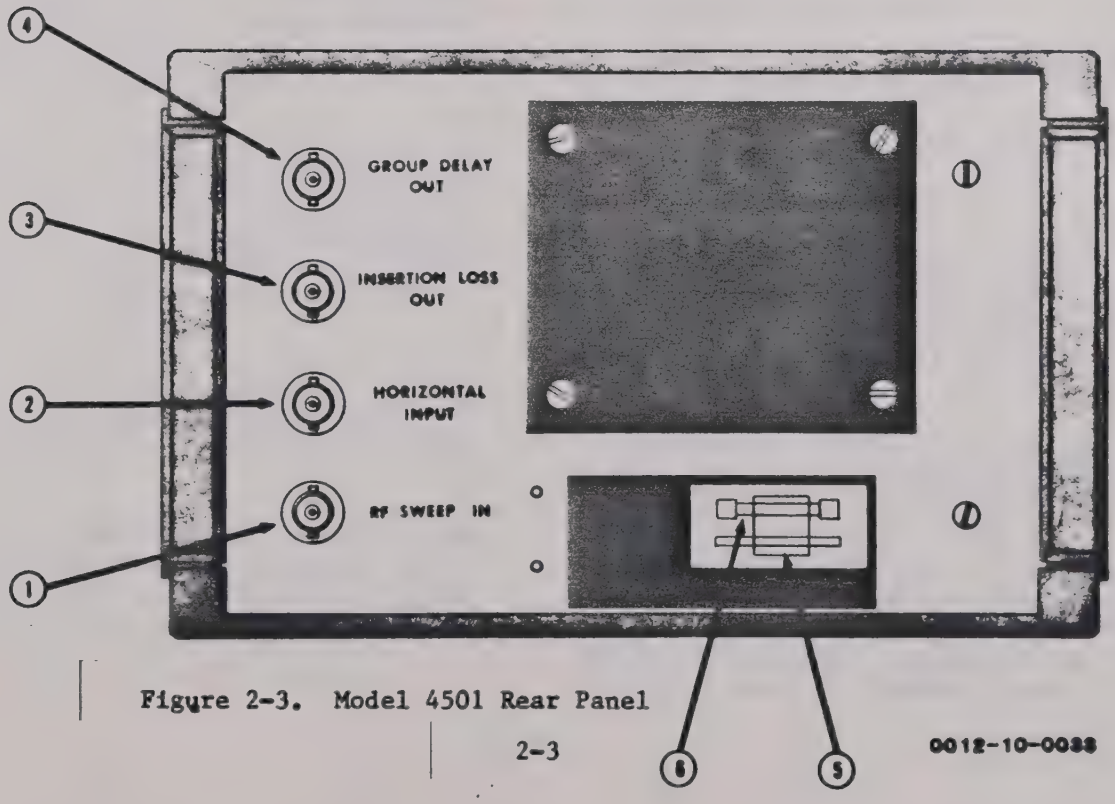
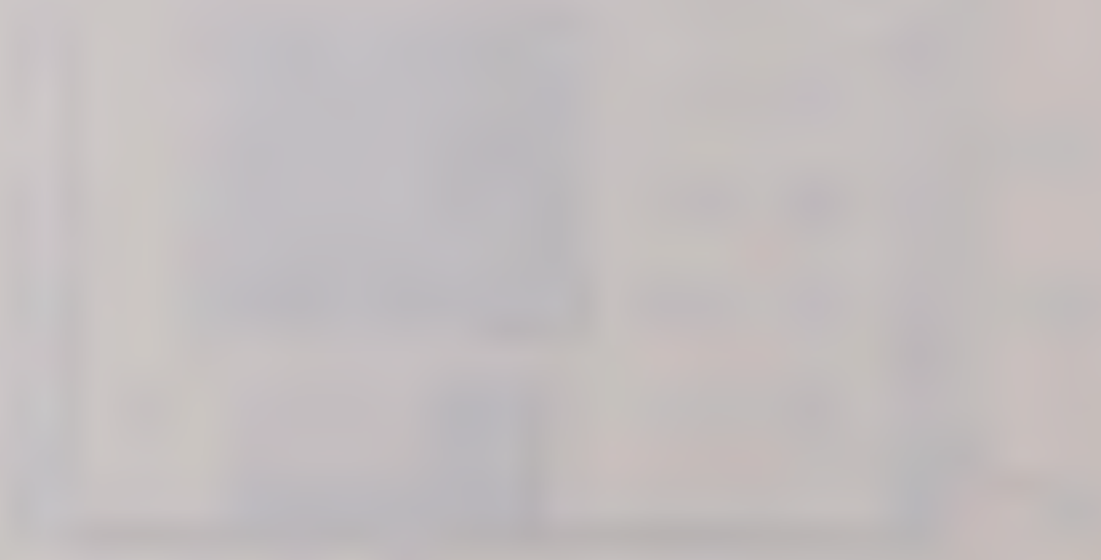


Figure 2-3. Model 4501 Rear Panel



deflection on the display. When measuring relative group delay, this control should be set to full counterclockwise (ccw). When measuring absolute group delay with Auto Offset turned off, this control with the Fine control is used to set a 0 ns reference on display. It may also be used as a vertical position control in place of the Model 4602's rear-panel Channel B Position control. Clockwise rotation produces increase in vertical deflection.

3) FINE CONTROL - This control is a 10-turn pot with 1 turn ≈ 33 mV ≈ 33 ns of vertical deflection on the display. When measuring relative group delay this control should be set to full clockwise (cw). Like the Coarse control, the Fine control is useful in setting a 0 ns reference, or as a vernier control for vertical positioning of the group delay trace. Clockwise rotation produces increase in vertical deflection.

4) RANGE SWITCH - The two frequency range positions (5 to 100 MHz and 100 to 1500 MHz) are set to the applicable device-under-test (DUT) input frequency characteristics. Some frequency overlap is present in each position. Care should be exercised in matching the switch position to the DUT.

5) UNLEVELED LIGHT - The red LED is turned on when the output level from the DUT is outside the prescribed limits for group delay measurements. The output level may be too high or too low. It occurs during blanking, and this is normal.

6) OUTPUT CONNECTOR (TYPE N) - The input of the DUT is connected here. The VSWR of the connecting cable should be $\leq$ 1.2.

7) INPUT CONNECTOR (TYPE N) - The output of the DUT is connected here. The VSWR of the connecting cable should also be $\leq$ 1.2.

8) VIDEO FILTER - When the video filter is selected, noise is removed from the group delay trace. Sweep rate is normally set to 1 Hz with the video filter turned on. With the video filter turned off the sweep rate may be increased to aid in signal searching, or in making device adjustments.

9) CALIBRATION CONTROLS - When any one of the three switches is pressed, an abrupt decrease in the vertical deflection of the group delay trace occurs in the final half of the display. If the vertical display is calibrated, (Gain control full CW), the following deflections occur:

Switch	V/DIV	Deflection
10 ns	0.01	1 div
100 ns	0.1	1 div
1000 ns	1.0	1 div

When used with the appropriate vertical display sensitivity, a convenient group delay calibration check is available to the operator.

10) PILOT LIGHT - A green LED is on when AC power is turned on.

11) POWER SWITCH - When depressed, power is applied to the unit.

2.5 MODEL 4501 REAR PANEL DESCRIPTION

See Figure 2-3.

1) RF SWEEP IN - The input from an RF sweep generator such as the Wavetek Model 2002B is injected here. Normal level is +3 dBm. SWR of connecting cable should be $\leq$ 1.5.

2) HORIZONTAL INPUT - The horizontal output ramp of a sweep generator is connected here (0 to +10 V at 10 kΩ).

3) INSERTION LOSS OUT - A signal proportional to insertion loss of the DUT is available here. This unit output is normally connected to the Channel A input of the Model 4602.

4) GROUP DELAY OUT - A signal proportional to the group delay of the DUT is available here. This unit output is normally connected to the Channel B input of the Model 4602.

5) FUSE - Install the correct fuse: 1 A slo-blo for 120 VAC, and 500 mA for 240 VAC operation.

6) VOLTAGE SELECTION CARD - Observe that the proper line voltage is visible from the window.

2.6 MODEL 4602 FRONT PANEL DESCRIPTION

See Figure 2-4.

1) INTENSITY - Controls the brightness of both A and B traces. When pin-ball or intensity markers are displayed, the brightness should be decreased.

2) GAIN CHANNEL A - When pot is full cw, the vertical sensitivity is calibrated; when full ccw the sensitivity is about 1/10 the calibrated setting. When INSERTION LOSS signal from Model 4501 is connected to rear-panel Channel A input, both switch and vernier are used to set display. Display is usually not inverted.

3) V/DIV CHANNEL A - Position of switch determines vertical sensitivity of display - calibrated when Gain Channel A is full cw.

4) GAIN CHANNEL B - Adjusted to full CW for calibrated display. Permits adjustment for vertical sensitivities to 1/10 of calibrated display.

5) V/DIV CHANNEL B - Usually controls group delay sensitivity. Calibrated when Gain Channel B is full CW.

6) B CHANNEL - When depressed Channel B (group delay signal) is displayed.

7) A CHANNEL - When depressed Channel A (insertion loss signal) is displayed. Both A and B may be depressed together for dual trace displays.

8) POWER - When switch is depressed, power is applied to the unit.

2.7 MODEL 4602 REAR PANEL DESCRIPTION

See Figure 2-5.

NOTE: All rear panel connectors are BNC

1) CHANNEL A INPUT - The INSERTION LOSS signal from the Model 4501 is injected here.

2) CHANNEL A POSITION - Controls the vertical position of the A trace on the display (the insertion loss signal).

3) CHANNEL B POSITION - Controls the vertical position of the B trace on the display (the group delay signal).

4) GRATICULE INTENSITY - This control adjusts the brightness of the graticule on the display. Should normally be set to lower brightness than the display trace.

5) BLANKING INPUT - Blanking signal from pin 5 of the 2002B rear panel is connected here. This signal blanks the A and B channel displays during sweep retrace.

6) HORIZONTAL INPUT - The horizontal ramp (0 to 10 V) from the Model 2002B (SCOPE HORIZ) is injected here.

7) MARKER INPUT - Permits pin-ball markers to be displayed on the dual traces. The VERT OUT signal from the Model 2002B is connected here.

8) FUSE - Install the correct fuse - 2 A slo-blo for 120 VAC, and 1 A slo-blo for 240 VAC.

9) VOLTAGE SELECTION CARD - Observe that the proper line voltage is visible from the window.

10) CHANNEL B INPUT - The GROUP DELAY signal from the Model 4501 is connected here.

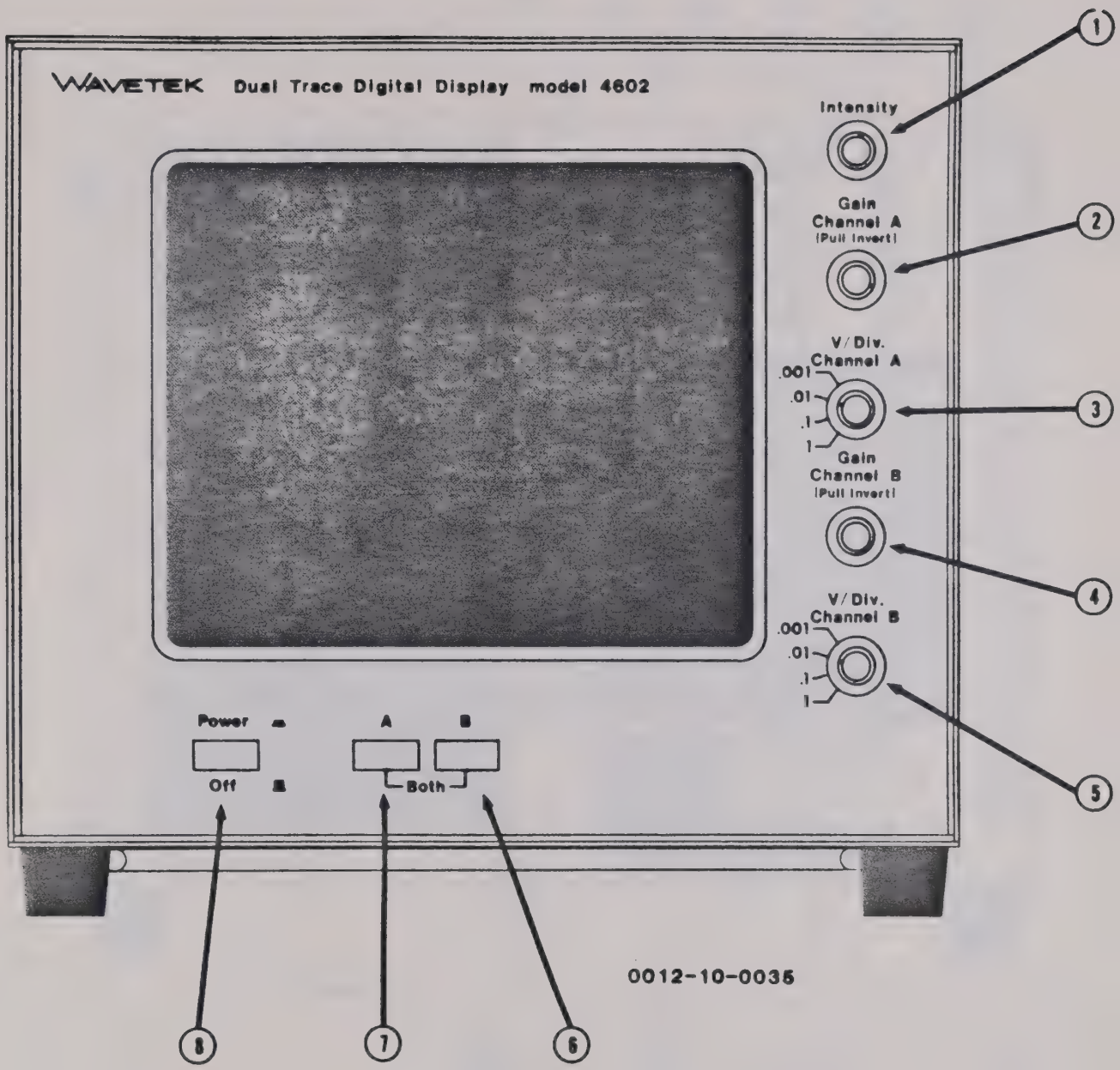


Figure 2-4. Model 4602 Front Panel

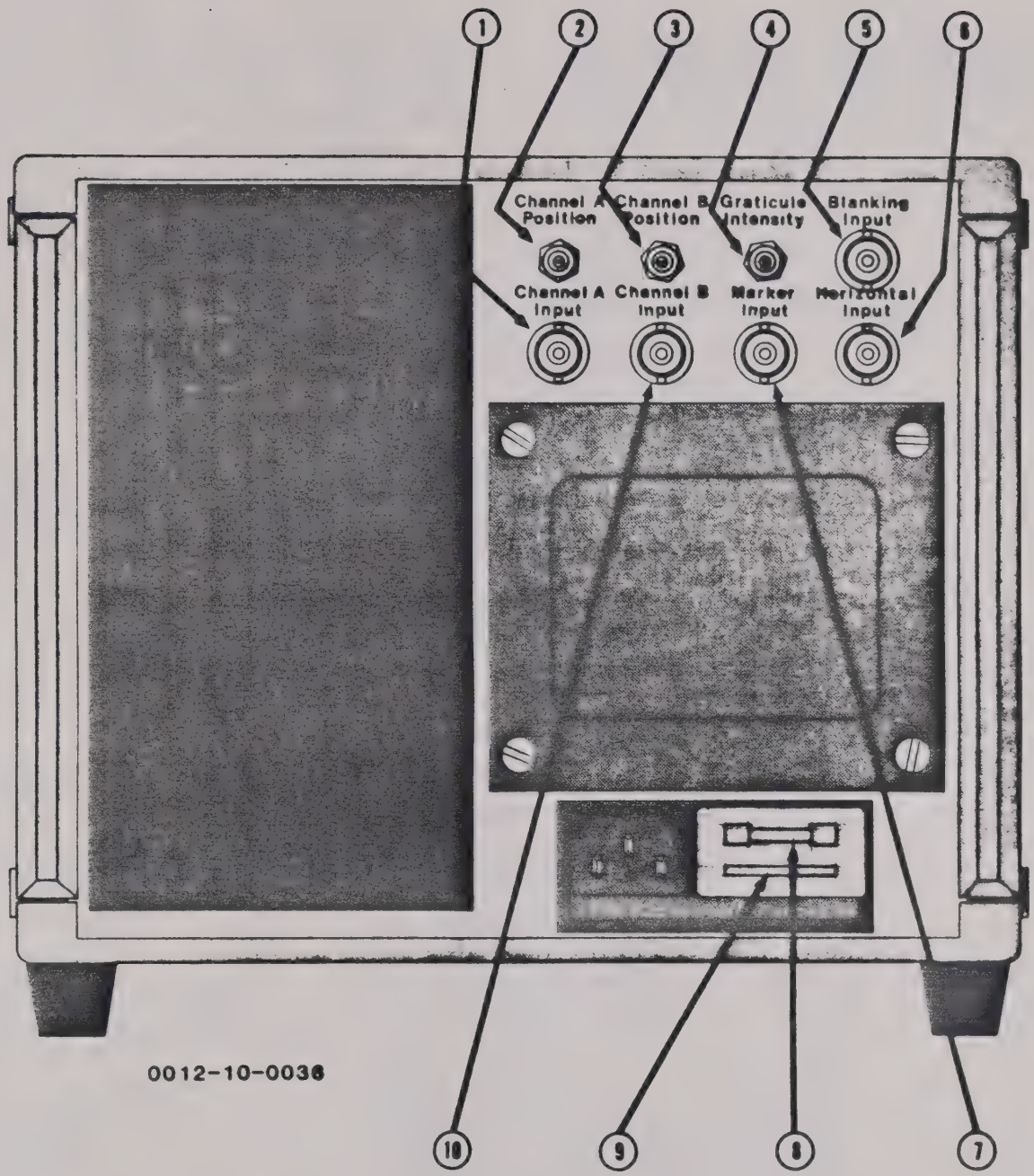


Figure 2-5. Model 4602 Rear Panel

2.8 TYPICAL TEST SETUP

A typical test setup is shown in Figure 2-6. The RF cable between the sweeper and the rear-panel RF SWEEP IN connector should have reasonable VSWR ($\leq$ 1.5) and be as short as possible. The leads to the DEVICE UNDER TEST and the front-panel Input and Output connectors should have low VSWR ($\leq$ 1.2), and be as short as possible.

2.9 RELATIVE GROUP DELAY MEASUREMENT

1. Device Under Test: Bandpass Filter

2. Set up equipment as shown in Figure 2-6. Cables from DUT to Model 4501 and from sweeper to Model 4501 should have SWR $\leq$ 1.2.

3. Set 2002B controls:

Mode	Δf
Sweep Width	$\simeq$ 100 MHz (reduce as needed)
Center Frequency	To center freq of DUT
Sweep Time	$\simeq$ 0.5 sec
Trig	Recur
Blanking	On
ALC	Int

4. Set 4501 controls:

Auto Offset	On
Coarse	Full CCW
Fine	Full CW
Video Filter	Off
Calibration	Not selected

5. Depending upon filter characteristics, set 4602 controls:

FP = front panel	RP = rear panel
Intensity (FP)	For acceptable viewing
Graticule Intensity (RP)	Bright enough to see
For insertion loss trace	Press A
V/Div Channel A	.1 to .01
Channel A Position (RP)	Adjust as needed
For group delay trace	Press B
V/Div Channel B	.1 to .01
Gain Channel B	Full CW (for calibrated display)
Channel B Position (RP)	Adjust as needed

6. When properly adjusted a typical display is shown in Figure 2-7. To display markers first turn down the 4602 Intensity until the trace is just visible. Then set the HARMONIC markers on the 2002B to the desired frequency, the MARKER size to maximum, and the MARKER width to wide. The pin-ball markers should be visible in the display. Adjust the 2002B MARKER controls (size, width, and tilt) for the display.

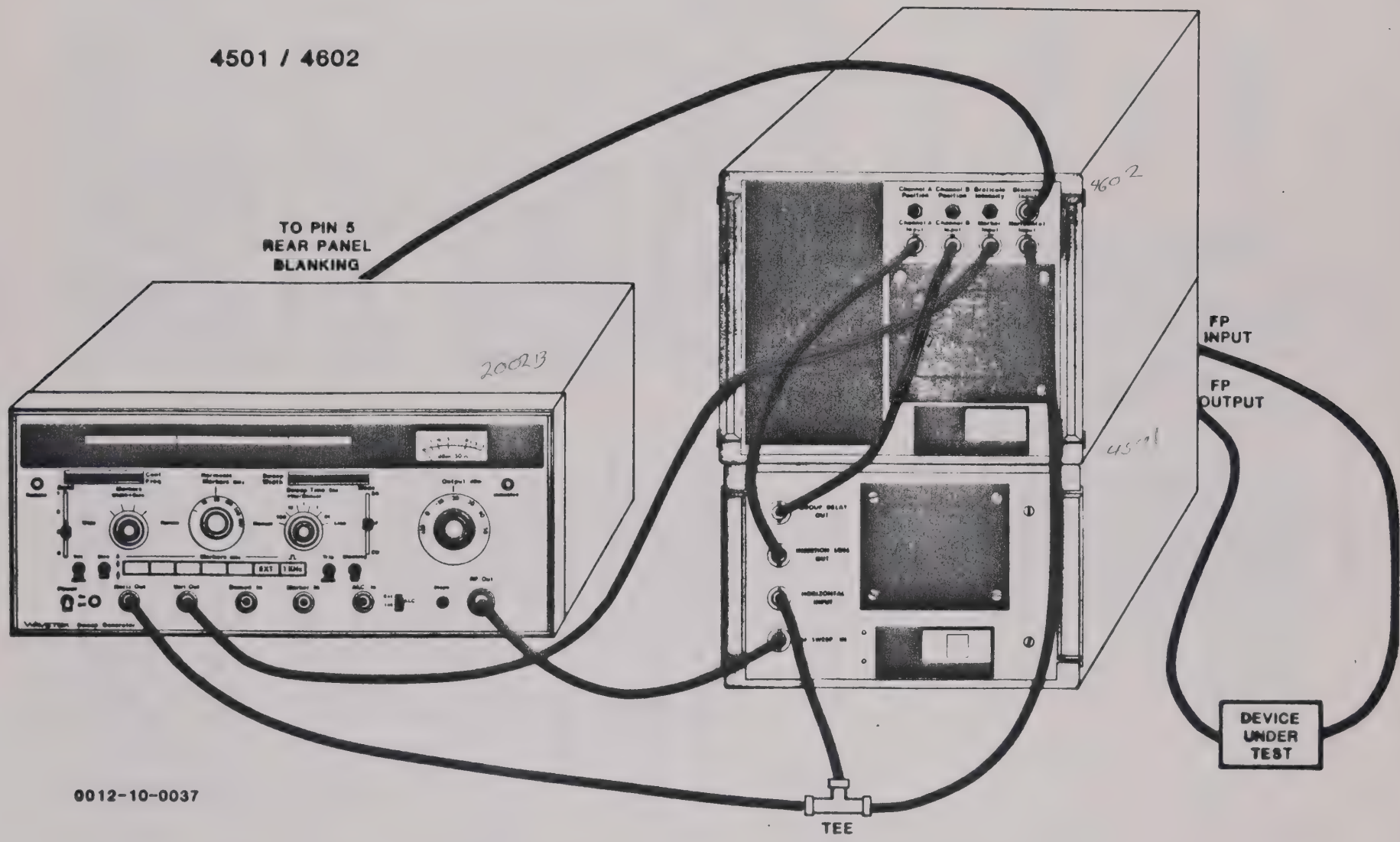


Figure 2-6. Typical Test Setup

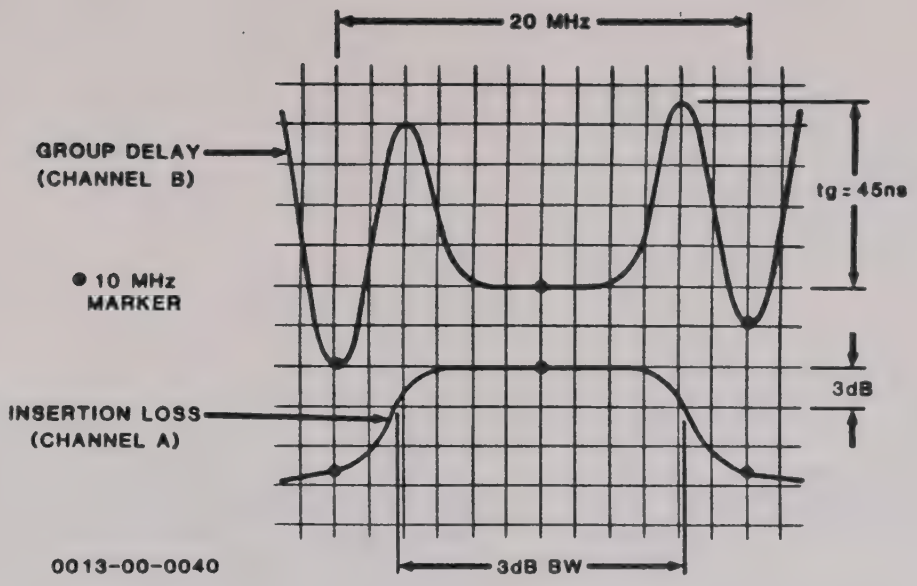


Figure 2-7. Bandpass Filter Characteristics

Markers may be used to calibrate the bandwidth of the filter, and to determine the group delay in the passband. Group delay measurements may be made within approximately the 6 dB bandwidth. Measurements outside this range show abrupt positive excursions of the trace and should be ignored.

Bandwidth may also be determined by reducing the output level of the 2002B below +3 dBm. For instance, the sweeper's level can be reduced 3 dB to find the 3 dB loss reference line. When the sweeper level is returned to +3 dBm, the filter's 3 dB points are found where the insertion loss trace crosses this reference line.

NOTE: When making absolute delay measurements, it is recommended the 4501 warm up for a minimum of one hour.

2.10 ABSOLUTE GROUP DELAY MEASUREMENT

Most group delay measurements are made within a 6 dB passband of a device as described in the relative group delay measurement. The relative group delay measurement is usually of greatest interest. However, the Model 4501 can be used to measure absolute group delay. The technique is as follows:

1. Establish a 0 ns-delay reference.

a. Connect a low SWR short between the Input and Output connectors on the Model 4501.

b. Turn off the Auto Offset.

c. Use a combination of Coarse and Fine control adjustments to position the display trace on the bottom graticule line. (Selection of the vertical deflection sensitivity may require more than one trial).

2. Measure absolute group delay.

a. Do not disturb controls affecting vertical sensitivity.

b. Connect DUT to Input and Output connectors using low SWR cables.

c. The absolute group delay is the change in deflection in ns (1 ns = 1 mV) between the 0 ns reference line and the point of interest on the group delay trace of the DUT.

SECTION 3

THEORY OF OPERATION

3.1 INTRODUCTION

Group delay is defined as the rate of change, with angular frequency, of the total phase shift through an electrical network. It can be measured in real time using the Nyquist-Brant technique of detecting the phase shift of a modulated frequency source. An RF source is modulated and the phase shift of the modulation is measured. The group delay is then determined according to the expression:

$$P/(F \times 360°)$$

where P = the modulation phase shift in degrees and F = the modulation frequency in Hz.

The resulting group delay is thus expressed in seconds (more typically nanoseconds; 1 nsec = 10^{-9}sec).

In the Model 4501, the modulation frequency used is 20 kHz, thus a 7° phase shift would result in a group delay of 7°/(20,000 Hz x 360°) = 972 nsec.

The instrument can thus be considered a special type of phase meter. A pulse modulated RF carrier is applied to the device under test. The modulated carrier is then returned to the instrument where it is demodulated (by envelope detection) and compared to the original modulating signal to determine the phase shift. The phase shift data is expressed as a function of the RF carrier frequency. Since the RF carrier can be swept, the group delay across a range of frequencies can be determined.

3.2 MODEL 4501

A block diagram of the Model 4501 Group Delay Analyzer is shown in Figure 2-1. A description of each card follows.

3.2.1 CALIBRATE CARD

The calibrate card provides four 20 kHz outputs. Two reference outputs, the servo reference and the phase detector reference are used on the phase detector board. Two modulation outputs, low-band modulation and high-band modulation are used on the transmit board. Only one of modulation outputs is active at a time with the unused output railed positive.

In order to insure utilization of the entire phase detector range, the inherent phase relation between the modulation signals and the phase detector reference signal is balanced by two variable phase shift networks. These are adjusted with R31, R44, R56, and R72.

There is also a calibrated phase shifter activated by one of three calibration buttons on the front panel. This circuit delays the modulation by an amount of time indicated on the front panel. The delay occurs only in the second half of the sweep and thus displays a calibration step on the trace.

The front panel offset, auto-offset, and servo correction signals are all summed into a voltage controlled phase shifter. This circuit delays the phase detector reference signal in order to

compensate for temperature changes or large absolute delays in the device-under-test.

3.2.2 TRANSMITTER CARD

The primary purpose of the transmitter card or board is to modulate the RF carrier. This is done in two bands, 5-100 MHz and 100-1500 MHz. In the upper range, pulse modulation is used in order to minimize the effects of incidental PM. The lower range uses a more sinusoidal modulation in order to reduce the frequency content of the modulation. Both modulators are followed by a high-pass filter to remove modulation harmonics from the RF path.

The RF input to the transmitter board is well buffered to isolate the source's leveler from the modulator dynamic impedance. The output is also well buffered to provide good VSWR to the device under test.

3.2.3 RECEIVER MODULE

The input to the receiver module is also well buffered to provide good VSWR to the device under test. After the first amplifier stage, the RF is then resistively split into two paths - group delay and insertion loss.

At the split point the RF level varies with frequency just as the DUT amplitude response. Therefore, the insertion loss information is recovered by amplifying and then AM detecting. The output of the detector then goes to the output board for filtering.

To reduce AM to PM conversion of the AM detector the group delay path contains a leveler. The leveler is a PIN attenuator controlled by the AGC correction signal from the output board. Following the PIN attenuator are 5 stages of gain to compensate for the loss of the attenuator and the DUT.

3.2.4 PHASE DETECTOR CARD

The RF output from the receiver module goes to the phase detector board where it is AM detected. The output of the detector is buffered and then split into two paths.

One path contains more amplification and an audio detector. The output of the audio detector is then used to generate the AGC correction signal on the output board.

The other path filters the 20 kHz before applying it to a limiter. The limiter converts the 20 kHz sine wave back to a square wave so it can be phase compared to the original 20 kHz. The output of the phase detector is then amplified and filtered to provide a millivolt DC for every nanosecond delay.

The phase detector also contains another phase detector, amplifier and filter which helps temperature compensate the phase detectors.

3.2.5 OUTPUT CARD

The primary purpose of the output card is to buffer and blank the group delay voltage and to amplify, filter, and detect the insertion loss signal. However, the board also provides the AGC correction and the auto-offset feature.

The AGC correction is generated by buffering the output from the phase detector board and notch filtering 20 kHz and its harmonics. The resulting DC voltage is then compared to a reference and the difference integrated to provide the correction signal. If the correction signal goes above or below set limits, the unlevel detector trips turning on the front panel indicator and blanking the group delay output.

The auto-offset feature works by sampling the group delay signal at the center of the trace and holding the sampled voltage until the sweeper retrace. At that time the voltage is gated to the voltage controlled phase shifter on the calibrate board which adjusts the offset as if to bring the trace center back to zero. On the next sweep the trace offset has been corrected. The voltage is passed to the calibrate board only when the auto-offset button is depressed.

3.3 MODEL 4602

The Model 4602 is basically an analog-to-digital-to-video converter which uses a raster scan to implement the signal displays. The unit consists of the following assemblies:

Power Supply (low voltage) Card #1
Data Acquisition Card #2
Address Generator Card #3
Memory/Dot Generator Card #4
Sync Generator/Video Combiner Card #5
Analog Conditioning Card #6
Video Monitor

The Video Monitor is a standard monochrome monitor including a +12 kV supply, a magnetic deflection yoke, and a 7-inch diagonal CRT. This assembly is located in the front compartment of the unit.

Power Supply Card #1 provides outputs of +5, +10, +12, +15, and -15 V. The 12 V output supplies the Video Monitor. Pass transistors and a bridge recitifier are mounted on the rear-panel heatsink.

4.1 INTRODUCTION

Separate performance tests on the Model 4501 and Model 4602 are documented in the following paragraphs. Tests should begin after a one-hour minimum warmup on both instruments. Make sure the tests are made in the specified temperature range, and at the specified voltage from the AC mains. See Section 1.

4.2 MODEL 4501 PERFORMANCE TESTS

NOTE

Make sure the sweeper output cable and the DUT cables have good VSWR and are no longer than necessary.

1. With the range switch set to 100-1500 MHz and the group delay output connected to a DVM verify that the group delay output voltage drops 1000mV ±20mV when the 1000 nSec calibrator is pushed; 100 mV ±2 mV when the 100 nSec calibrator is pushed; 10 mV ±1 mV when the 10 nSec calibrator is pushed. Set the range switch to 5-100 MHz and repeat this same test.

2. Turn the sweeper power down to -17 dBm and verify the unit does not unlevel from 5-1500 MHz.

NOTE

This will be checked in two steps 5-100 MHz and then 100-1500 MHz. If the unit does unlevel, turn down the AGC voltage via R14 on output card.

3. Turn the power back to +3 dBm, the range switch, and sweep back to 100-1500 MHz. Adjust the sweep rate to 10 Hz and verify that no more than 2 divisions are lost at the beginning of the sweep.

NOTE

This check is performed on the Group Delay output at 10mV/div on the oscilloscope.

4. Monitor the insertion loss output on the oscilloscope. Adjust the sweeper level to obtain +3dBm input into the analyzer and adjust the scope's offset and gain controls to obtain an RF detected level of 8 divisions at the low end of the sweep. Now adjust the slope control on the sweeper so that the peak at the high end matches the peak at the low end. Verify that the lowest point on the trace is not less than 4-divisions or 50% of maximum output level.

5. With the sweep set at 100 MHz CW verify that the group delay output noise is not more than

2 mVRMS	Video filter out
1 mVRMS	Video filter in

6. Remove the RF cable from the rear panel. Check return loss from 5-1500 MHz on both front panel ports. It should be greater than 20 dB.

7. With the sweeper level at +3 dBm and the sweep and range switch at 100-1500 MHz verify that the group delay trace varies no more than

±3 nSec	100-1000 MHz
±3 nSec	1000-1500 MHz
±5 nSec	100-1500 MHz

With the range switch and sweep at 5-100 MHz, verify that the group delay trace varies no more than

±20 nSec	5-20 MHz
±3 nSec	20-100 MHz

Use the signal generator and a DVM to make the 5-20 MHz and 20-100 MHz response test.

8. Activate the automatic offset function and note the location of the trace. Adjust the course offset control max ccw and verify that the trace has changed less than 50 mV.

4.3 MODEL 4602 PERFORMANCE TESTS

4.3.1 TEST EQUIPMENT NEEDED

1. Oscilloscope - Tektronix T922 or equivalent

2. Function Generator - Wavetek Model 190 or equivalent

3. Sweep Generator -Wavetek Model 2002B/2005 with 1-10-50-100 markers

4. DVM -Fluke 8012A or equivalent

5. 50Ω Attenuator - Wavetek Model 5070-1

6. Cables - 50Ω Coax Cables

4.3.2 TEST EQUIPMENT SETUP

1. Blanking of 2002B to Blanking Input 4602.

2. Horizontal of 2002B to Horizontal Input 4602.

3. Vert of 2002B to Marker Input 4602.

4. Output of Function Generator to Input Channel A 4602.

4.3.3 SET INSTRUMENT CONTROLS

1. SWEEP GENERATOR 2002B or 2005

Sweep Time	1 sec Vernier fully ccw
Markers	OFF
Markers Width/Size	Wide Vernier fully cw
MODE	Δf

Other Controls set for normal operation.

4.3.4 FUNCTION GENERATOR Wavetek Model 190 or equivalent

Function	Sine Wave
Freq	10 Hz
Voltage Output	4 Vpp
Mode	Cont

4.3.5 4602 DISPLAY SCOPE UNDER TEST

Intensity F.P.	Full cw
Gain Ch A and Ch B	Full cw
V/Div Ch A and Ch B	1 V/Div
Intensity R.P.	Full ccw

4.3.6 V/DIV PERFORMANCE CHECK

1. Set function generator for a 4 Vpp output at 10 Hz.

2. Connect function generator to Channel A of scope.

3. Push in button marked Channel A on front panel.

4. Adjust the position control on the rear panel of the 4602 so that the 10 Hz, 4 Vpp signal falls within four divisions on the CRT. This will become the reference point for the rest of the check.

5. Place a 70 dB (5070-1) attenuator between the output of the function generator, and the input of Channel A of the 4602. The attenuator should be set at the 0 dB attenuation point.

6. Attenuate the output by 20 dB and adjust the 1 V/Div to .1 V/Div. This .4 Vpp signal must remain within the same graticule reference.

7. Attenuate the output by a total of 40 dB and adjust the .1 V/Div to .01 V/Div. This .04 Vpp signal must remain within the same graticule reference.

8. Attenuate the output by a total of 60 dB and adjust the .01 V/Div to .001/Div. This .001 Vpp signal must remain in the graticule reference within ±1% of 4 divisions.

4.3.7 CHECK GAIN CONTROL PERFORMANCE

1. Set function generator for a 4 Vpp output at 10 Hz.

2. Connect function generator to Channel A of scope.

3. Push in button marked Channel A on front panel.

4. Adjust the position control on the rear panel of the 4602 so that the 10 Hz, 4 Vpp signal falls within four graticule divisions on the CRT. This will become the reference point for the rest of the check.

5. Adjust the V/Div to .1/Div and use the gain control knob ccw of Channel A so the signal is within the ref point. This is now a .4 Vpp signal. If you adjust the gain control fully ccw it will attenuate the output to something less than .4 Vpp with a minimum of 1/2 div offset.

Repeat Step 5 for Channel B.

4.3.8 LINEARITY CHECK

1. Set function generator for a 4 Vpp signal at 100 Hz.

2. Set Channel A to 1 V/Div gain fully cw.

3. With the position control on the back of the 4602, check that the amplitude remains the same across the CRT within ±1% of 4 graticule divisions. Check top, middle, and bottom of CRT.

4.3.9 VERTICAL INVERT CHECK

1. Set function generator for 1 Vpp signal at 10 Hz.

2. Set Channel A to 1 V/Div gain fully cw.

3. With the position control on the back of the 4602, adjust the 10 Hz 1 Vpp signal to fall within one graticule division.

4. Pull out the gain pot Channel A. This will invert the signal on Channel A. The inverted signal will have an offset of ±1/2 of one Div.

5. Repeat Steps 1 through 4 for Channel B.

4.3.10 INTENSITY CONTROL CHECK

1. Set function generator for 4 Vpp signal at 10 Hz.

2. Set Channel A to 1 V/Div and Channel B to 1 V/Div.

3. Output from function generator to inputs of scope Channel A and Channel B.

4. With position control, place Channel A Signal in the top portion of the graticule, and Signal B in the lower portion of the graticule.

5. With the front panel control fully cw and rear panel intensity control full counter cw, note that the signal intensity is brighter than the graticule.

6. Turn down the front panel intensity control ccw. Note that only the signal intensity is affected. The signal intensity must be totally blanked within a half-turn of the intensity knob. (Note: graticule lines may be blanked in areas where the signal is blanked.)

7. With the signal blanked out, turn the intensity control on the back of the 4602 until the graticule is blanked out. With the signal and the graticule fully blanked, the CRT must be dark.

4.3.11 MARKER CHECK

1. Set front panel intensity control fully cw.

2. Set rear panel intensity control cw until the graticules are half as bright as the signal intensity.

3. Set the 2002B Signal Generator as below:

MODE	Δf
SWEEP WIDTH	100 MHz
CENT FREQ	100 MHz
band	1

(Remember you must have the Vert of 2002B connected to the marker input of the 4602.)

4. Push in buttons on front panel marked A and B. Remove function generator.

5. Use the Channel A and Channel B position controls on the back panel of the 4602 to adjust the line traces so that they fall in the center of a graticule.

6. Adjust the front panel intensity control until the line trace is totally blanked (this will be about one-quarter of a turn).

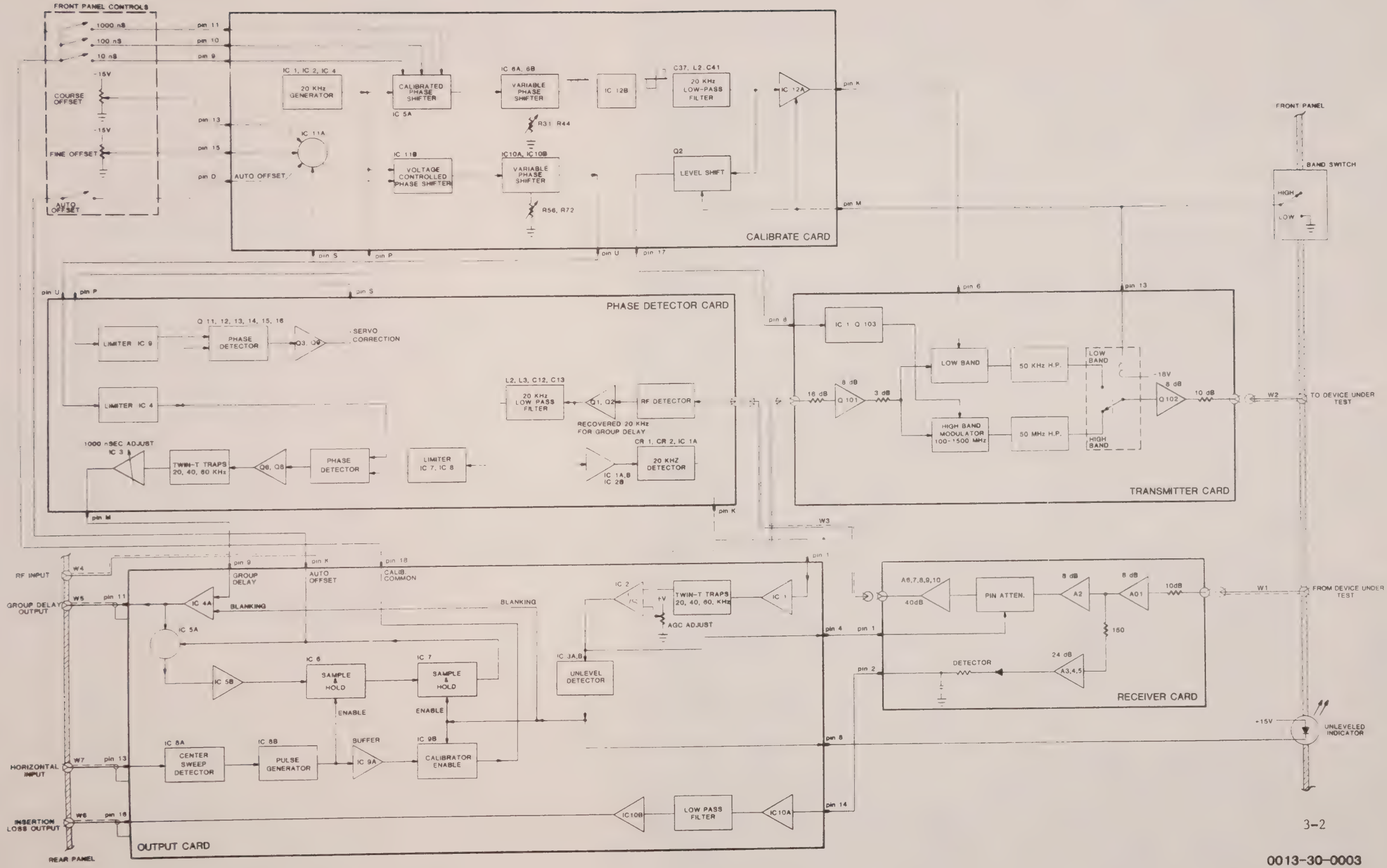
7. Turn on the 100 MHz marker using the 2002B marker control. A 100 MHz pin ball marker will appear center screen. (Remember that the markers need to be 1.5 Vpp coming from 2002B. If by chance the markers are larger than 1.5 Vpp, other markers or spurious noise may appear.

8. Turn on the 50 MHz marker. Now there are three pin ball markers on the screen; two 50 MHz markers located on either side of the 100 MHz marker.

9. Turn on the 10 MHz markers. There should be 11 pin ball markers on the screen.

10. Turn on the 1 MHz marker. The two traces will look almost solid. (Note: With markers on, the front panel intensity will not turn the traces totally off.)

11. Turn the front panel intensity fully cw. The two traces will now be solid. You may see some solid lines jumping to the top of the screen. This is to be considered normal (not to be in excess of two solid trace lines per one single sweep).


FRONT PANEL CONTROLS
1000 nS
100 nS
10 nS
COURSE OFFSET
FINE OFFSET
AUTO OFFSET
-15V
pin 11
pin 10
pin 9
pin 13
pin 15
pin D
AUTO OFFSET
IC 1, IC 2, IC 4
20 KHz GENERATOR
CALIBRATED PHASE SHIFTER
IC 5A
IC 11A
IC 11B
VOLTAGE CONTROLLED PHASE SHIFTER
IC 6A, 6B
VARIABLE PHASE SHIFTER
R31, R44
IC10A, IC10B
VARIABLE PHASE SHIFTER
R56, R72
IC 12B
C37, L2, C41
20 KHz LOW-PASS FILTER
IC 12A
Q2
LEVEL SHIFT
pin K
pin M
pin S
pin P
pin U
pin 17
CALIBRATE CARD
PHASE DETECTOR CARD
LIMITER IC 9
Q 11, 12, 13, 14, 15, 16
PHASE DETECTOR
Q3, Q4
SERVO CORRECTION
LIMITER IC 4
L2, L3, C12, C13
20 KHz LOW PASS FILTER
Q1, Q2
RF DETECTOR
RECOVERED 20 KHz FOR GROUP DELAY
1000 nSEC ADJUST IC 3
TWIN-T TRAPS 20, 40, 60 KHz
Q6, Q8
PHASE DETECTOR
LIMITER IC 7, IC 8
CR 1, CR 2, IC 1A
IC 1A,B IC 2B
20 KHZ DETECTOR
pin M
pin 6
pin 13
pin 8
IC 1 Q 103
LOW BAND
50 KHz H.P.
LOW BAND
-18V
HIGH BAND MODULATOR 100-1500 MHz
50 MHz H.P.
HIGH BAND
16 dB
8 dB
Q 101
3 dB
8 dB
Q 102
10 dB
W2
TO DEVICE UNDER TEST
W3
TRANSMITTER CARD
FRONT PANEL
BAND SWITCH
HIGH
LOW
RF INPUT
W4
GROUP DELAY OUTPUT
W5
pin 11
IC 4A
BLANKING
IC 5A
IC 5B
IC 6
SAMPLE & HOLD
ENABLE
IC 7
SAMPLE & HOLD
ENABLE
HORIZONTAL INPUT
W7
pin 13
IC 8A
CENTER SWEEP DETECTOR
IC 8B
PULSE GENERATOR
BUFFER
IC 9A
IC 9B
CALIBRATOR ENABLE
INSERTION LOSS OUTPUT
W6
pin 16
REAR PANEL
pin 9
GROUP DELAY
pin K
AUTO OFFSET
pin 18
CALIB. COMMON
OUTPUT CARD
IC 2
+V
AGC ADJUST
TWIN-T TRAPS 20, 40, 60, KHz
IC 1
pin 1
IC 3A,B
UNLEVEL DETECTOR
IC10B
LOW PASS FILTER
IC10A
pin 4
pin 1
pin 2
pin 8
pin 14
A6,7,8,9,10
40dB
PIN ATTEN.
8 dB
A2
8 dB
A01
10dB
150
DETECTOR
24 dB
A3,4,5
RECEIVER CARD
W1
FROM DEVICE UNDER TEST
+15V
UNLEVELED INDICATOR

WAVETEK
INDIANA, INC.

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CERTIFICATION OF TRACEABILITY

TO THE

NATIONAL BUREAU OF STANDARDS

WAVETEK INDIANA, INC., hereby certifies that the instrument and/or component listed below has been manufactured and calibrated, wherever applicable and available, with instruments and standards traceable to those set forth, maintained and established by the United States Department of Commerce, National Bureau of Standards.

WAVETEK MODEL: 4501 SERIAL NO: 5262231

NOMENCLATURE: GROUP DELAY ANALYZER

WAVETEK INDIANA, INC.
5808 Churchman Avenue
Beech Grove, IN 46107

DATE: 11-22-85 BY: _____
Quality Coordinator

WAVETEK
INDIANA, INC.

5808 Churchman, Beech Grove, Indiana 46107
Tel. 317/788-9351 • TWX 810-341-3226

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WAVETEK INDIANA, INC., hereby certifies that the instrument and/or component listed below has been manufactured and calibrated, wherever applicable and available, with instruments and standards traceable to those set forth, maintained and established by the United States Department of Commerce, National Bureau of Standards.

WAVETEK MODEL: 4602 SERIAL NO: 4552040

NOMENCLATURE: DISPLAY SCOPE

WAVETEK INDIANA, INC.
5808 Churchman Avenue
Beech Grove, IN 46107

DATE: 11-22-85 BY: Don Hoop
Quality Coordinator

MP MASTER
MA35654